WHITE PAPER

Critical Components of Industrial-Grade Wireless Devices

Jeffrey Ke
Product Manager

Mark Wu
Technical Writer

MOXA®

Executive Summary

For hard-to-wire locations and constantly-changing work landscapes with moving equipment and heavy machinery, such as applications commonly found at mining sites, wireless connectivity is the ideal solution for providing highly flexible and efficient network communication. However, most industrial applications require a stable and reliable wireless network that can only be achieved with industrial-grade wireless devices.

Industrial operators using commercial-grade wireless devices for mission-critical wireless applications may be getting satisfactory wireless network service, but frequent maintenance and system downtime can add up to a high total cost of ownership. In this paper, we reveal many harmful effects commonly found in industrial environments that can quickly disable a commercial-grade wireless device, and discuss the types of protection an industrial-grade wireless device should provide to ensure continuous wireless network communication.

Overview

Wireless failures at home or in the office will be an inconvenience until a replacement device is installed. Wireless network failures in industrial applications, however, can jeopardize the safety of onsite personnel, damage expensive machinery/equipment, and possibly translate into thousands of dollars per minute in production losses. In addition to network redundancy, industrial operators must also assess the application environment for elements that can impact network performance, compromise device reliability, and lead to unplanned system downtime.

Many industrial wireless applications, such as those for mining, railway, and oil & gas, are deployed in harsh environments and require the use of industrial-grade devices. While some environmental factors are obvious, such as extreme temperatures and moisture, there are other elements that are not so apparent but can also quickly disable an unprotected device. Below is a list of environmental conditions and effects commonly found in industrial wireless applications that can cause a device to malfunction or fail entirely.

- Power interference
- Magnetic field/emissions
- Flammable gases
- Extreme temperatures
- Humidity and moisture
- Airborne particles and contaminants
- Shock and vibration

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How to contact Moxa
Tel: 1-714-528-6777
Fax: 1-714-528-6778

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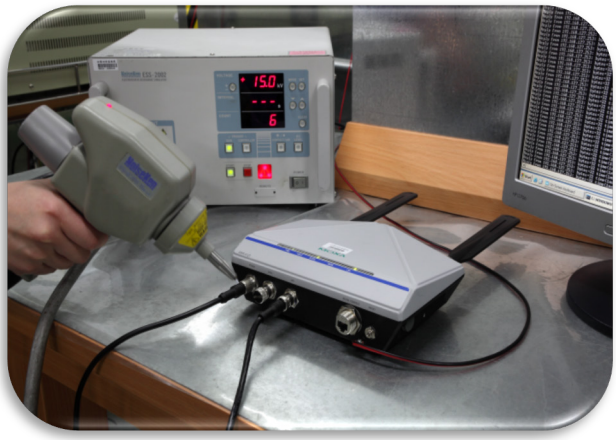
Industrial-Grade Protection for Wireless Devices

Electromagnetic Susceptibility (EMS)

According to the International Electrotechnical Commission (IEC)[1], EMS is defined as, "*The inability of a device, circuit, or system to perform without degradation in the presence of an electromagnetic disturbance.*" Below are common types of electromagnetic disturbances that can interfere with device operation.

- **Electrostatic Discharge (ESD)**
  ESD is the sudden transfer of static electricity between two objects with different electrical potentials. For example, factory workers wearing rubber boots and gloves can easily accumulate high levels of static electricity. Physical contact with wireless devices can discharge several kilovolts (kV) of static electricity and permanently damage internal circuitry.



- **Surge/Burst/Electrical Fast Transients (EFT)**
  Switching disturbances, short circuits, and especially lightning strikes, can inject high-level voltage spikes to cause serious damage to wireless devices. Surge protection devices (SPDs), such as transient voltage surge suppressors (TVSS), metal oxide varistors (MOV), and gas discharge tubes (GDT), are necessary to provide industrial-grade protection against electrical transients.

  - Switching disturbances
    Industrial high-powered equipment/machinery can require large amounts of energy to switch on and turn off components such as motors and hydraulic systems. This switching can abruptly generate high quantities of power flow, disrupting the steady voltage flow in the electrical system, which can be

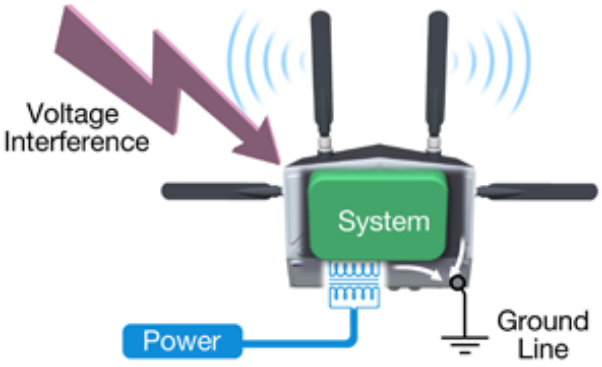
severe enough to instantly damage, or gradually degrade, device system circuitry.

- Short circuits
  Accidental contact or unintended paths of two points in a circuit with different line potentials can cause a short circuit. In addition to yielding high levels of electrical surge and disturbance that can potentially damage device circuitry, short circuits can also generate intense heat, damage/burn wire insulations, and even cause fires/explosions.

- Lightning strikes
  Protection against direct lightning strikes requires the installation of a lightning rod (lightning conductor) to direct the massive amount of electricity quickly to the ground terminal. However, when lightning strikes, or is directed to, ground, surrounding wireless equipment can also be affected by the sudden rise in voltage because wireless equipment is also grounded.

- **Electrical Field Emissions (Radiated)**
  Not to be confused with conducted electromagnetic emissions, electrical field emissions can affect almost every device. Electromagnetic radiation can be emitted by one device to generate RF currents in surrounding devices, causing electromagnetic disturbances and even possibly damaging a device. RF shielding, such as metallic device housings, can effectively repel electrical field emissions. Antenna isolation, as described in the next section (Galvanic Isolation Protection), can also eliminate the damaging effects caused by electromagnetic radiation.

Galvanic Isolation Protection



Transformers are generally used for changing voltages, but when used for circuit isolation, isolation transformers can transfer power between two physically-separated circuits to provide protection against electrical shocks, and prevent excessive electrical currents from entering the system when ground loops have different electrical potentials. Antennas on wireless devices can also be galvanically isolated to provide total isolation of internal device circuitry and further protection from electromagnetic disturbances.

Ingress Protection (IP)

Ingress protection is highly desirable for outdoor applications, where precipitation and/or debris can quickly penetrate the device housing, causing system performance deterioration and even permanent damage to the printed circuit board (PCB). Ingress protection ratings (labeled as IP##) are used to indicate precise information about the level of protection a device offers against solid particles and liquids. For example, a wireless access point with an

IP68 rating is completely air tight and can be submersed under water for long periods of time. See below for more detailed information about ingress protection.

IP # #

Protection against solid objects
0: no protection
1: ≥ 50 mm in diameter
2: ≥ 12.5 mm in diameter
3: ≥ 2.5 mm in diameter
4: ≥ 1.0 mm in diameter
5: dust resistant
6: air tight protection

Protection against liquids
0: no protection
1: dripping vertically
2: dripping (when tilted up to 15°)
3: spraying
4: splashing
5: jetting
6: powerful jetting
7: temporary immersion
8: continuous immersion

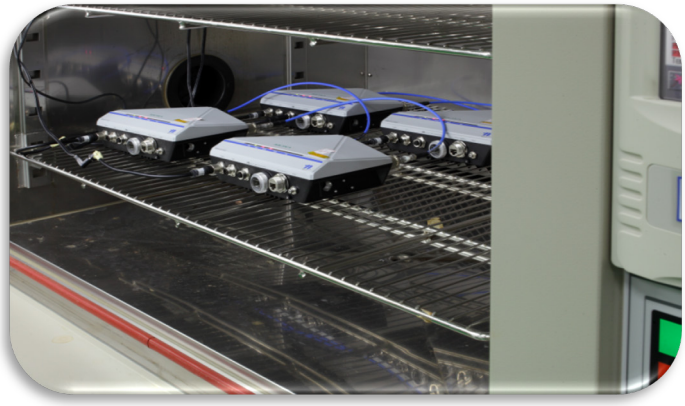
Shock/Vibration Protection

Wireless connectivity is generally deployed for industrial applications where network flexibility is required, especially for moving vehicles, heavy machinery, and job sites that are constantly relocating, which can expose wireless devices to shock and vibration. Long-term exposure to shock and vibration can eventually result in electrical shorts, broken solder joints, loose PCB components, PCB delamination, and cracked device housings.

Shock and vibration can also disable a wireless device by shaking loose wires for power, data, and redundancy. Power, data, and redundant connections should be securely fastened to the device with terminal block, M12, or QMA connectors to prevent unintentional disconnections.

Extreme Temperature Protection

Extreme outdoor temperatures can reach below freezing at night, and rise to an excess of 50°C (122°F) during the day. Temperatures inside roadside cabinets can even reach extreme temperatures of over 60°C (140°F). Thermal stress/cycling will cause PCBs to expand and contract, which can also cause broken solder joints and PCB delamination.



Commercial-grade wireless devices may seem adequate for applications in air-conditioned environments, but are at risk of overheating when air-conditioning systems fail. Wireless network reliability should not be compromised by the failure of the air-conditioning system. For mission-critical wireless applications, operators should consider the possibility of deploying a fully-industrial wireless network.

Industrial Wireless Networks Need Industrial-Grade Devices

Conventional wireless networks, such as those found at the library or local coffee shop, typically provide only a best-effort level of service, and does not guarantee the user a level of service for packet delivery, transmission speed, or redundancy. Industrial wireless networks with mission-critical applications will have low latency-tolerance and must operate uninterrupted with high reliability, which can only be ensured with the deployment of industrial-grade wireless devices.

What many operators may not realize, and where many industrial wireless devices can fail, is that the use of commercial-grade wireless devices can present unforeseen vulnerabilities. Deploying a fully-industrial wireless network will require a greater initial investment, but the benefits of improved network uptime, enhanced network performance, and reduced maintenance costs will all contribute to a lower total cost of ownership.

For more information on how industrial-grade wireless devices can benefit your mission-critical wireless application, please visit: www.moxa.com/Industrial_Wireless_LAN.htm

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Credits/sources

1. Redoute, Jean-Michel and Steyaert, Michiel. EMC of Analog Integrated Circuits. *Springer, 2010. Print.*